

National Exams December 2009

04-Geom-A3, Geodesy and Positioning

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK EXAM.
No calculator is needed nor permitted in this exam.
3. SIX (6) questions constitute a complete exam paper.
The first six questions as they appear in the answer book will be marked.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

1. Coordinate Systems

Suppose that you want to determine your position in terms of astronomical latitude and longitude (Φ , Λ) using astronomical observations to the Sun. Your observations are performed in the Local Astronomic (LA) coordinate system, whereas the position of the Sun is known in the Apparent Right Ascension system (or Apparent Places AP-system).

- Which are the quantities (observables) are you need to measure?
- In what coordinate system would your position (Φ , Λ) be referenced?
- Write the transformation equation between LA and AP that establishes the mathematical relationship between your position (Φ , Λ) and the position of the Sun. Please use rotation matrices and explain the angles involved.

2. Height systems

Modern trends in height determination are usually described by the term “GPS levelling”. With GPS levelling it is possible to determine the orthometric height of any point on or above the surface of the Earth.

- Define *orthometric height* and the reference surface it refers to.
- Describe briefly how we can determine the orthometric height of a point using GPS positioning. You can use simple geometrical relations or sketches to illustrate your answer.
- What is the accuracy of GPS levelling? Can GPS levelling achieve similar accuracies to the geodetic (spirit) levelling? Please justify your answer.

3. Map projections

- Define azimuthal, conic and cylindrical projections (i.e., with respect to the projection surface)
- What is conformal mapping?
- Tissot’s indicatrix: what is it and what does it express?

4. Inertial positioning, or Inertial Navigation Systems – INS

- The main components of an INS are three (3) accelerometers and three (3) gyroscopes. Please describe their role in INS relative positioning.
- Discuss briefly three error sources in inertial navigation and a possible way to eliminate them
- What is ZUPT and how is it used in INS positioning?

5. Satellite Positioning

- One of the major sources of errors in GPS positioning is *atmospheric refraction*. Please describe how this error occurs, by distinguishing two main atmospheric layers, namely the *troposphere* and *ionosphere*. What is the order of magnitude of the error in point positioning due to refraction?
- GPS satellites transmit two distinct carrier waves (signals), at two different frequencies in the L-band. What is the purpose of the dual frequency signals?

6. Gravity field

- Define *gravity anomaly* in its most generic form. Based on your definition of the gravity anomaly define *free-air gravity* anomaly.
- What is a *plumb line*? Why are the plumb lines of the Earth’s gravity field curved? Can we say the same for the plumb lines of the Earth’s gravitational field, or of the normal gravity field? Please explain.

7. Briefly describe the terms below (3-4 sentences for each). Sketches or graphs, wherever possible, are acceptable:
- a) Earth precession
 - b) UTM
 - c) Sidereal time
 - d) geoid
 - e) VLBI
 - f) Line of apsides
 - g) Argument of the perigee
 - h) NAD83
 - i) Canadian Base Network (CBN)
 - j) ITRF

Marking Scheme

1. 20 marks total (5 marks for 1(a), 5 marks for 1(b) and 10 marks for 1(c)).
2. 20 marks total
 - (a) 6 marks
 - (b) 8 marks
 - (c) 6 marks
3. 20 marks total
 - (a) 6 marks
 - (b) 6 marks
 - (c) 8 marks
4. 20 marks total
 - (a) 7 marks
 - (b) 9 marks
 - (c) 4 marks
5. 20 marks total (10 marks each)
6. 20 marks total (10 marks each)
7. 20 marks total (2 marks each item)